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ZUMBRO LAKE, OLMSTED AND WABASHA COUNTIES, MINNESOTA

Pacific Northwest Environmental Research Laboratory

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July 1975

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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REPORT
ON
ZUMBRO LAKE
OLMSTED AND WABASHA COUNTIES
MINNESOTA

EPA REGION V

WORKING PAPER No. 137

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

JULY, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

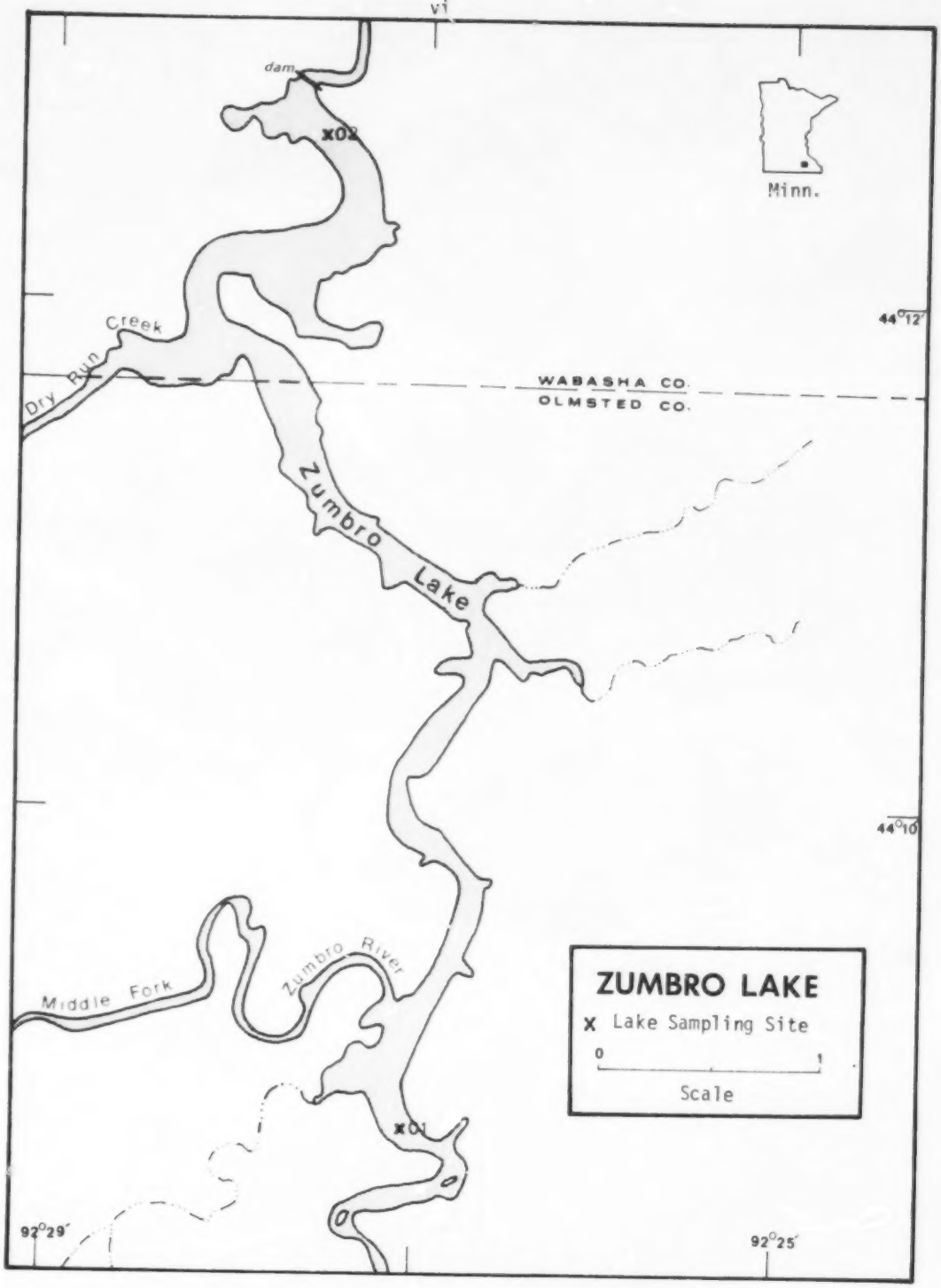
NATIONAL EUTROPHICATION SURVEY

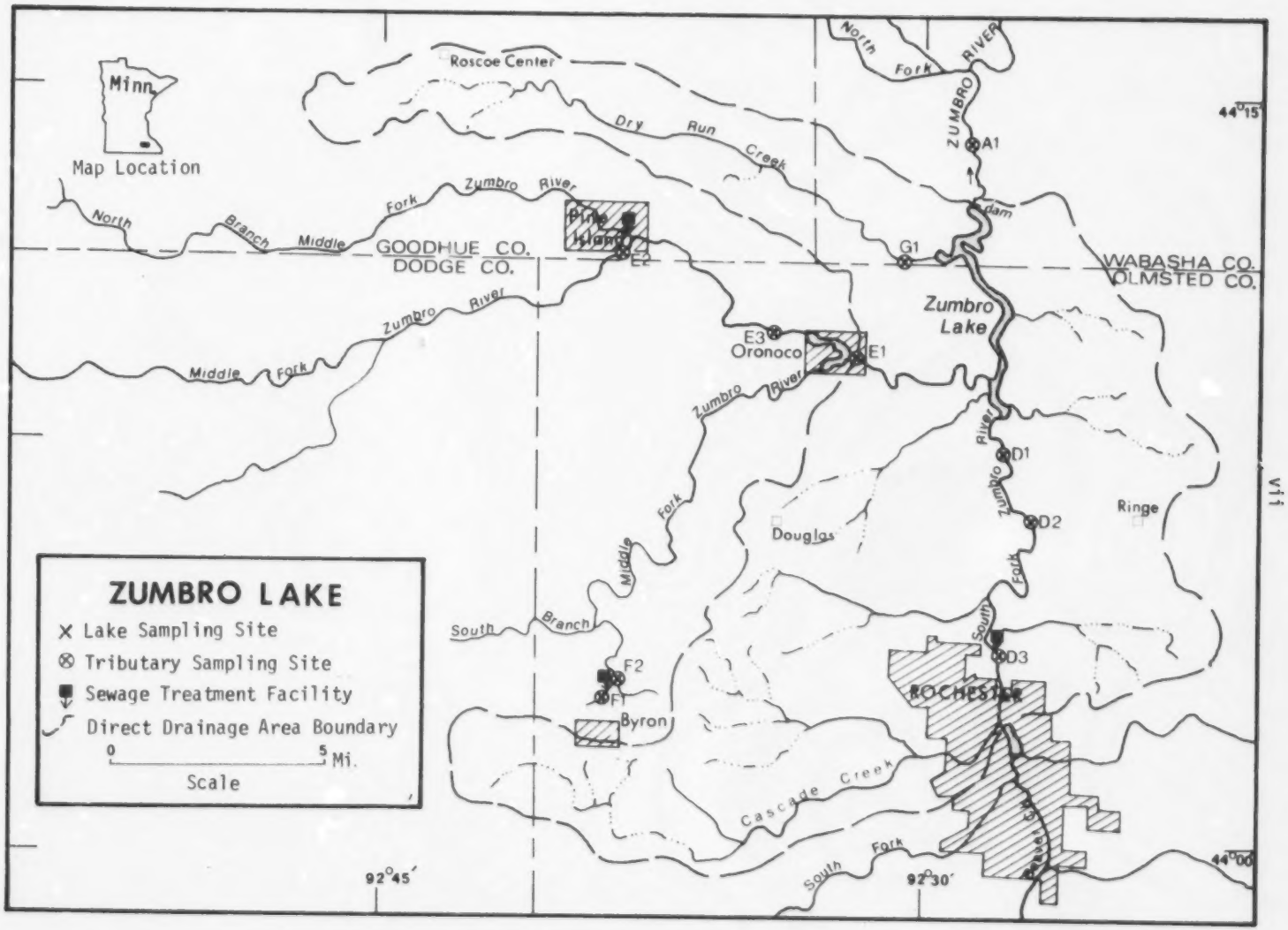
STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


dam
x02
Minn.
44°12'
Dry Run Creek
WABASHA CO.
OLMSTED CO.
Zumbro Lake
44°10'
Middle Fork
Zumbro River
x01
92°29'
92°25'
ZUMBRO LAKE
X Lake Sampling Site
0
1
Scale


Minn.
Map Location
Roscoe Center
North Fork
ZUMBRO RIVER
Dry Run Creek
A1
dam
44°15'
North Branch Middle Fork Zumbro River
Pine Island
E2
GOODHUE CO.
DODGE CO.
G1
WABASHA CO.
OLMSTED CO.
Zumbro Lake
E3
Oronoco
E1
Middle Fork Zumbro River
Zumbro River
D1
Douglas
Zumbro River
D2
Ringe
Middle Fork
South Branch
South Fork
D3
F2
F1
Byron
ROCHESTER
Cascade Creek
South Fork
92°45'
92°30'
44°00'
ZUMBRO LAKE
X Lake Sampling Site
⊗ Tributary Sampling Site
Sewage Treatment Facility
Direct Drainage Area Boundary
0
5 Mi.
Scale

ZUMBRO LAKE

STORET NO. 27A5

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Zumbro Lake is eutrophic. Of the 60 Minnesota lakes sampled in the fall of 1972 when essentially all were well-mixed, 49 had less mean total phosphorus, 51 had less mean dissolved phosphorus, and all had less mean inorganic nitrogen. For all Minnesota data, 31 lakes had less mean chlorophyll a, and 30 had a greater mean Secchi disc transparency.

Survey limnologists noted intensive algal blooms in progress during the June and August sampling visits.

B. Rate-Limiting Nutrient:

A significant loss of nutrients occurred in the algal assay sample between the time of collection and the beginning of the assay, and the results are not representative of conditions in the lake at the time the sample was taken (11/03/72). The lake data indicate nitrogen limitation during the June and August sampling periods and phosphorus limitation during the November sampling.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Zumbro Lake received a total phosphorus load at a rate 52 times the rate

proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 14). However, the mean hydraulic retention time of Zumbro Lake is less than ten days, and it is likely that Vollenweider's model does not apply. Nonetheless, the existing trophic condition of the lake is evidence of excessive nutrient loads.

It is calculated that the City of Rochester and the villages of Byron and Pine Island collectively contributed nearly 83% of the total phosphorus load to Zumbro Lake. In the following table, the total phosphorus loading rates that can be achieved by specified levels of phosphorus removal at all three point sources are shown and compared to Vollenweider's suggested rates.

	Total P Loading	
% P Removal	lbs/acre/yr	$g/m^2/yr$
Existing	1,159.9	130.00
50	680.4	76.27
70	488.7	54.77
80	392.8	44.03
90	296.9	33.28
100	201.0	22.53
Vollenweider:		
Eutrophic rate		2.50
Oligotrophic rate		1.25

It will be noted that none of the removal options given above would result in an optimal loading rate. In fact, even with 100% removal at the point sources, the loading would be about nine times the eutrophic rate. However, in view of the questionable applicability of Vollenweider's model to Zumbro Lake, it is likely that a high degree of point-source phosphorus removal would result in persistent phosphorus limitation in the lake and a significant reduction in the incidence and severity of nuisance algal blooms.

Attention is called to the exceptionally large phosphorus load measured at the Pine Island wastewater treatment plant (equivalent to more than 15 pounds per capita per year). As far as is known, a creamery is the only industrial nutrient source contributing to the treatment plant (Schilling, 1974). Further study is needed to identify the source of this excess phosphorus.

2. Non-point sources--The mean phosphorus export rate of the Zumbro Lake tributaries was 93 lbs/mi^2/yr and ranged from 91 pounds to 95 pounds (see page 14). The export rates compare very well with the mean export of tributaries to nearby Lake Pepin* (154 lbs/mi^2/yr).

* Working Paper No. 119.

In all, it is calculated that non-point sources, excluding precipitation, contributed about 17% of the total phosphorus load to Zumbro Lake during the Survey sampling year.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 391 acres.
2. Mean depth: 10 feet.
3. Maximum depth: 48 feet.
4. Volume: 3,910 acre-feet.
5. Mean hydraulic retention time: 6.5 days.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
S. Fork, Zumbro River	365.0 mi^2	131.5 cfs
Middle Fork, Zumbro River	441.0 mi^2	154.8 cfs
Dry Run Creek	29.0 mi^2	9.5 cfs
Minor tributaries & immediate drainage -	16.4 mi^2	6.4 cfs
Totals	851.4 mi^2	302.2 cfs

2. Outlet -

Zumbro River	852.0 mi^2**	302.2 cfs**

C. Precipitation***:

1. Year of sampling: 36.6 inches.
2. Mean annual 28.5 inches.

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† McGuire, 1973.
* Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 1, "Survey Methods, 1972".

III. LAKE WATER QUALITY SUMMARY

Zumbro Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page vi). During each visit a single depth-integrated (15 feet to surface) sample was composited from the two stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 30 feet at station 1 and 40 feet at station 2.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/03/72)		
Temperature (Cent.)	6.6	6.8	6.9	7.0
Dissolved oxygen (mg/l)	9.0	9.5	9.4	10.0
Conductivity (μmhos)	570	578	570	600
pH (units)	7.5	7.6	7.6	7.8
Alkalinity (mg/l)	160	186	183	232
Total P (mg/l)	0.300	0.311	0.310	0.329
Dissolved P (mg/l)	0.254	0.268	0.265	0.280
NO_2 + NO_3 (mg/l)	4.940	5.380	5.305	6.250
Ammonia (mg/l)	0.250	0.372	0.420	0.440
		ALL VALUES		
Secchi disc (inches)	10	59	44	118

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/28/72	1. Anabaena	8,840
	2. Melosira	688
	3. Stephanodiscus	652
	4. Dinobryon	652
	5. Cryptomonas	362
	Other genera	1,089
	Total	12,283
08/27/72	1. Melosira	1,474
	2. Stephanodiscus	271
	3. Flagellates	126
	4. Anabaena	108
	5. Navicula	72
	Other genera	426
	Total	2,477
11/03/72	1. Cylindrocystis	4,171
	2. Flagellates	1,407
	3. Anabaena	754
	4. Dinobryon	754
	5. Microcystis	603
	Other genera	3,668
	Total	11,357

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/28/72	01	38.6
	02	25.1
08/27/72	01	0.5
	02	6.0
11/03/72	01	2.6
	02	2.0

C. Limiting Nutrient Study:

A 53% loss of dissolved phosphorus occurred in the algal assay sample between the time of collection and the beginning of the assay, and the results are not representative of conditions in the lake at the time the sample was taken (11/03/72). The lake data indicate nitrogen limitation during the June and August sampling periods (N/P ratios were 5/1) and phosphorus limitation during the November sampling (N/P = 21/1).

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vii), except for the high runoff months of April and May when two samples were collected. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean concentrations at unimpacted sampling stations (e.g., stations D-3, F-1, E-2, and G-1) and the mean flows. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the nutrient loads, in $lbs/mi^2/year$, in Dry Run Creek at station G-1 and multiplying by the ZZ area in mi^2.

The operators of the wastewater treatment plants at the City of Rochester and the villages of Byron and Pine Island provided monthly effluent samples and corresponding flow data. Nutrient loadings for the Village of Oronoco were estimated as septic tank loads.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Rochester	53,766	trickling filter	8.714	S. Fk., Zumbro River
Pine Island	1,640	act. sludge	0.469	Middle Fk., Zumbro River
Byron	1,419	act. sludge	0.175	Middle Fk., Zumbro River
Oronoco	564	septic tanks	unknown	Middle Fk., Zumbro River

2. Known industrial** -

Name	Treatment	Mean Flow (mgd)	Receiving Water
?Creamery	Pine Island STP	0.230	Middle Fk., Zumbro River

* Anonymous, 1974.
** Schilling, 1974.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
S. Fk., Zumbro River	34,120	7.5
Middle Fk., Zumbro River	39,970	8.8
Dry Run Creek	2,750	0.6
b. Minor tributaries & immediate drainage (non-point load) -	1,560	0.3
c. Known municipal STP's -		
Rochester	345,930	76.3
Pine Island	25,000	5.5
Byron	3,980	0.9
d. Septic tanks* -	140	<0.1
e. Known industrial -		
Creamery (to Pine Island STP)	-	-
f. Direct precipitation** -	60	<0.1
Total	453,510	100.0

2. Outputs -

Lake outlet - Zumbro River 200,490

3. Net annual P accumulation - 253,020 pounds

* Estimate based on a population of 564 at Oronoco; see Working Paper No. 1.
** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
S. Fk., Zumbro River	1,051,880	33.9
Middle Fk., Zumbro River	1,411,540	45.6
Dry Run Creek	68,280	2.2
b. Minor tributaries & immediate drainage (non-point load) -	38,610	1.2
c. Known municipal -		
Rochester	500,340	16.2
Pine Island	5,570	0.2
Byron	10,540	0.4
d. Septic tanks* -	5,300	0.2
e. Known industrial -		
Creamery (to Pine Island STP)	-	-
f. Direct precipitation** -	3,770	0.1
Total	3,095,830	100.0

2. Outputs -

Lake outlet - Zumbro River 2,927,600

3. Net annual N accumulation - 168,230 pounds

* Estimate based on a population of 564 at Oronoco; see Working Paper No. 1.

** See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs $P/mi^2/yr$	lbs $N/mi^2/yr$
S. Fk., Zumbro River	93	2,882
Middle Fk., Zumbro River	91	3,201
Dry Run Creek	95	2,354

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	1,159.9	647.1	7,917.7	430.3
grams/m^2/yr	130.00	72.53	887.5	48.2

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Zumbro Lake:

"Dangerous" (eutrophic rate)	2.50
"Permissible" (oligotrophic rate)	1.25

V. LITERATURE REVIEWED

Anonymous, 1974. Wastewater disposal facilities inventory. MPCA, Minneapolis.

McGuire, John F., 1973. Personal communication (lake morphometry). MPCA, Minneapolis.

Schilling, Joel, 1974. Personal communication (lake map; industrial wastes). MPCA, Minneapolis.

Vollenweider, Richard A. (in press). Input-output models. Schweiz. Z. Hydrol.

VI. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27A5 ZUMBRO LAKE

TOTAL DRAINAGE AREA OF LAKE 852.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
27A5A1	852.00	110.50	163.00	721.10	701.80	379.50	462.30	269.90	209.10	159.30	158.40	147.40	132.60	301.65
27A5D1	365.00	42.50	61.70	303.00	312.00	174.00	217.00	121.00	86.20	68.80	71.40	63.40	54.30	131.47
27A5E1	441.00	45.40	69.10	366.00	382.00	205.00	256.00	140.00	99.70	75.60	81.80	73.20	61.00	154.85
27A5G1	29.00	2.41	2.96	21.10	21.90	13.30	17.70	9.66	5.72	5.98	4.96	3.88	3.66	9.46
27A5ZZ	17.10	2.52	3.26	12.40	12.40	8.62	10.40	6.39	4.56	4.58	4.14	3.17	3.58	6.35

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 852.00
SUM OF SUB-DRAINAGE AREAS = 852.10
TOTAL FLOW IN = 3619.85
TOTAL FLOW OUT = 3614.90

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27A5A1	10	72	513.00	15	282.00				
	11	72	540.00	5	702.00				
	12	72	436.00	3	266.00				
	1	73	828.00						
	2	73	320.00	4	397.00				
	3	73	2540.00	4	4140.00				
	4	73	1890.00	8	794.00	20	2230.00		
	5	73	2390.00	5	2510.00	20	860.00		
	6	73	668.00	2	895.00				
	7	73	646.00	14	329.00				
	8	73	725.00	26	1290.00				
	9	73	819.00	19	286.00				
27A5D1	10	72	213.00	15	117.00				
	11	72	214.00	5	278.00				
	12	72	164.00	3	100.00				
	1	73	293.00						
	2	73	112.00	4	143.00				
	3	73	976.00	4	1590.00				
	4	73	774.00	8	325.00	20	913.00		
	5	73	1010.00	5	1060.00	20	364.00		
	6	73	289.00	2	387.00				
	7	73	284.00	14	144.00				
	8	73	239.00	26	469.00				
	9	73	354.00	16	124.00				

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27A5 ZUMBRO LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27A5E1	10	72	244.00	15	134.00				
	11	72	248.00	5	322.00				
	12	72	184.00	3	112.00				
	1	73	317.00						
	2	73	125.00	4	160.00				
	3	73	1180.00	4	1920.00				
	4	73	947.00	8	348.00	20	1120.00		
	5	73	1190.00	5	1250.00	20	428.00		
	6	73	340.00	2	456.00				
	7	73	329.00	14	168.00				
	8	73	246.00	26	543.00				
	9	73	389.00	19	136.00				
27A5G1	10	72	14.80	15	8.14				
	11	72	13.10	5	17.00				
	12	72	11.00	3	6.70				
	1	73	16.50						
	2	73	5.36	4	6.90				
	3	73	67.90	4	111.00				
	4	73	54.30	8	23.00	20	64.00		
	5	73	77.30	5	81.00	20	28.00		
	6	73	23.50	2	32.00				
	7	73	22.70	14	11.60				
	8	73	19.80	26	31.10				
	9	73	30.80	16	10.80				
27A5Z2	10	72	12.20	15	6.70				
	11	72	9.96	5	13.00				
	12	72	12.10	3	7.40				
	1	73	17.40						
	2	73	5.90	4	7.60				
	3	73	39.90	4	65.00				
	4	73	30.80	8	13.00	20	36.00		
	5	73	50.10	5	53.00	20	18.00		
	6	73	13.80	2	18.00				
	7	73	15.00	14	7.65				
	8	73	15.80	26	24.80				
	9	73	23.60	16	8.26				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

27A501
44 40 00.0 093 10 00.0
ZUMBRO LAKE
27 MINNESOTA

11EPALES 2111202
6 0030 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/28	14 30	0000	23.7	18.0	48	420	8.40	208	1.200	0.050	0.214	0.167
	14 30	0015	20.5	18.0								
	14 30	0030	16.3	0.4		520	7.39	262	0.880	1.700	0.710	0.694
72/08/27	14 30	0000			118	510	8.05	200	1.420	0.750	0.393	0.384
	14 30	0004	22.6	5.6		580	8.10	220	1.740	0.710	0.417	0.398
	14 30	0015	21.9	1.4		599	7.60	205	1.300	1.060	0.660	0.630
	14 30	0022	21.3	1.5		599	7.60	238	1.630	1.230	0.660	0.620
	14 30	0029	19.4	3.6		610	7.50	238	1.250	1.530	1.010	0.910
72/11/03	11 40	0000			10	580	7.80	216	4.940	0.250	0.309	0.265
	11 40	0004	6.6	10.0		570	7.80	192	5.120	0.250	0.320	0.254
	11 40	0018	6.7	10.0		600	7.80	212	5.540	0.360	0.321	0.280

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/28	14 30	0000	38.6J
72/08/27	14 30	0000	0.5J
72/11/03	11 40	0000	2.6J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/10/30

27A502
44 40 00.0 093 10 00.0
ZUMBRO LAKE
27 MINNESOTA

11EPALES 2111202
5 0022 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/28	14 55	0000	23.0	16.2	40	450	8.35	224	1.200	0.040	0.266	0.228
	14 55	0020	20.8	4.7		520	7.72	254	1.200	0.690	0.490	0.414
72/08/27	14 10	0000			118	560	7.85	170	1.410	0.870	0.410	0.409
	14 10	0004	22.5	4.4		550	7.85	200	1.540	0.870	0.424	0.381
	14 10	0015	21.9	2.7		590	7.75	200	1.420	0.990	0.540	0.488
	14 10	0022	21.6	1.4		600	7.60	200	1.400	0.020	0.590	0.520
	14 10	0030	19.2	2.1		600	7.50	245	1.640	0.020	0.660	0.253
72/11/03	11 15	0000			20	570	7.60	186	6.250	0.420	0.311	0.280
	11 15	0004	6.9	9.4		570	7.60	180	5.410	0.420	0.300	0.267
	11 15	0015	6.9	9.4		570	7.60	160	5.170	0.420	0.329	0.266
	11 15	0025	6.9	9.4		570	7.50	160	5.400	0.420	0.301	0.265
	11 15	0040	7.0	9.0		590	7.50	160	5.210	0.440	0.301	0.265

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/28	14 55	0000	25.1J
72/08/27	14 10	0000	6.0J
72/11/03	11 15	0000	2.0J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/10/30

27A5A1 LS27A5A1
44 14 00.0 092 29 00.0
ZUMBRO RIVER
27 15 ROCHESTER
0/ZUMBRO LAKE
CO HWY 7 BRDG ABOUT .5 MI NZUMBRO LK OTL
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	10 10		3.200	0.850	0.252	0.250	0.310
72/11/05	10 15		3.400	1.260	0.170	0.180	0.300
72/12/03	10 25		5.000	0.180	0.180	0.260	0.300
73/01/07	13 50		3.600	1.000	0.440	0.520	0.590
73/02/04	10 45		3.200	1.200	0.570	0.400	0.440
73/03/04	10 00		3.200	1.700	0.640	0.580	0.630
73/04/08	10 35		4.400	1.500	0.210	0.210	0.250
73/04/20	08 25		5.000	3.000	0.600	0.132	0.260
73/05/05	08 50		4.600	1.600	0.105	0.130	0.260
73/05/20	09 40		4.900	0.250	0.110	0.160	0.200
73/06/02	11 45		3.000	1.400	0.152	0.123	0.220
73/07/14	11 35		2.400	2.100	0.252	0.210	0.270
73/08/26	11 00		1.880	1.470	0.190	0.260	0.350
73/09/16	09 25		2.900	0.710	0.110	0.300	0.340

STORET RETRIEVAL DATE 74/10/30

27A5D1 LS27A5D1
44 08 00.0 092 27 30.0
S FORK ZUMBRO RIVER
27 15 ROCHESTER
1/ZUMBRO LAKE
CO HWY 21 BRDG 5 MI N ROCHESTER
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	09 30		3.000	1.500	0.540		1.020
72/11/05	09 45		3.800	1.050	0.230	0.310	0.430
72/12/03	09 55		4.700		0.720	0.950	1.040
73/02/04	10 20		3.700	0.760	0.520	0.850	0.915
73/03/04	09 30		1.760	0.500	2.500	0.520	0.945
73/04/08	10 10		3.300	1.260	0.350	0.530	0.610
73/04/20	08 05		4.200	1.950	0.220	0.230	0.320
73/05/05	08 30		4.500	1.000	0.120	0.190	0.280
73/05/20	09 10		4.100	0.600	0.273	0.470	0.525
73/06/02	11 25		4.000	2.310	0.200	0.370	0.470
73/07/14	11 10		3.800	2.400	0.310	0.710	0.920
73/08/26	10 05		3.000	1.470	0.220	0.330	0.440
73/09/16	09 05		3.900	1.150	0.297	0.960	1.050

STORET RETRIEVAL DATE 74/10/30

27A5D2 LS27A5D2
44 06 30.0 092 27 00.0
SOUTH FORK ZUMBRO RIVER
27 15 ROCHESTER
T/ZUMBRO LAKE
CO HWY 14 BRDG 2.5 MI W OF RINGE
11[illegible]ALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	09 15		2.300	2.900	0.530	0.130	0.870
72/11/05	09 30		3.300	1.000	0.220	0.260	0.359
72/12/03	09 45		4.700	0.840	0.680	0.850	0.940
73/01/07	13 15		4.300	0.780	0.322	0.500	0.560
73/02/04	10 00		3.700	0.930	0.410	0.710	0.750
73/03/04	09 30		1.740	6.100	1.680	0.500	0.900
73/04/08	09 55		3.300	1.470	0.370	0.560	0.660
73/04/20	07 55		4.400	1.380	0.300	0.200	0.280
73/05/05	08 20		4.600	0.500	0.105	0.189	0.280
73/05/20	09 00		4.100	1.760	0.252	0.390	0.450
73/06/02	11 05		4.000	1.700	0.198	0.370	0.470
73/07/14	10 55		3.700	2.300	0.245	0.595	0.760
73/09/26	09 50		3.000	1.600	0.220	0.320	0.440
73/09/16	08 50		3.800	0.690	0.273	0.750	0.830

STORET RETRIEVAL DATE 74/10/30

27A5D3 LS27A5D3
44 02 30.0 092 28 00.0
SOUTH FORK ZUMBRO RIVER
27 15 ROCHESTER
T/ZUMBRO LAKE
CO HWY 22 BRDG N ROCHESTER ABV STP
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	11 00		0.065	0.700	0.064	0.052	0.092
72/11/05	09 05		4.000	0.840	0.066	0.066	0.126
72/12/03	09 30		4.400	0.100K	0.092	0.038	0.085
73/01/07	13 00		4.200	0.310	0.100	0.050	0.090
73/02/04	09 50		3.500	0.350	0.075	0.035	0.085
73/03/04	09 00		1.700	6.200	1.680	0.430	0.760
73/04/08	09 50		3.200	1.150	0.031	0.024	0.045
73/04/20	07 45		5.100	1.380	0.063	0.048	0.105
73/05/05	08 05		4.600	0.540	0.052	0.054	0.110
73/05/20	08 40		3.900	0.230	0.027	0.031	0.060
73/06/02	10 50		3.900	0.440	0.023	0.032	0.065
73/07/14	10 35		3.000	1.470	0.154	0.092	0.155
73/08/26	09 30		3.000	1.200	0.091	0.092	0.165
73/09/16	08 20		3.300	0.675	0.063	0.058	0.120

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A5E1 LS27A5F1
44 10 00.0 092 32 00.0
MIDDLE FORK ZUMBRO RIVER
27 7.5 ORONOCO
T/ZUMBRO LAKE
CO HWY 18 BRDG AT ORONOCO
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	11 00		1.240	0.100K	0.096	0.130	0.189
72/11/05	10 50		4.500	0.170	0.113	0.093	0.168
72/12/03	10 50		6.100	0.100K	0.063	0.115	0.132
73/02/04	11 15		3.500	0.270	0.160	0.126	0.145
73/03/04	10 35		2.200	7.400	2.300	0.650	1.050
73/04/08	11 00		5.500	0.670	0.023	0.063	0.085
73/04/20	08 40		7.000	2.400	0.110	0.075	0.135
73/05/05	09 15		7.300	0.100K	0.031	0.078	0.160
73/05/20	10 05		4.700	0.610	0.046	0.050	0.110
73/06/02	12 10		4.400	0.750	0.025	0.058	0.118
73/07/14	12 05		1.880	1.950	0.220	0.132	0.230
73/08/26	11 35		5.200	1.470	0.088	0.147	0.260
73/09/16	09 55		2.700	1.680	0.085	0.105	0.160

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A5E2 LS27A5E2
44 12 00.0 092 38 30.0
MIDDLE FORK ZUMBRO RIVER
27 7.5 PINE ISLAND
T/ZUMBRO LAKE
RD BRDG SE PINE IS & ABOVE STP
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	11 40		1.420	0.100K	0.048	0.045	0.069
72/11/05	11 30		4.500	0.452	0.037	0.056	0.120
72/12/03	11 15		7.580	0.100K	0.019	0.031	0.044
73/03/04	11 05		2.300	7.350	2.900	0.560	0.880
73/04/08	11 25		6.900	0.100K	0.010	0.019	0.025
73/04/20	09 10		8.600	2.520	0.120	0.042	0.090
73/05/05	09 40		9.600	0.150	0.030	0.060	0.145
73/05/20	11 00		5.800	0.420	0.009	0.019	0.040
73/06/07	13 10		5.600	0.880	0.022	0.015	0.040
73/07/14	13 25		2.100	3.700	0.105	0.063	0.085
73/08/26	13 10		8.300	2.700	0.300	0.091	0.145
73/09/16	10 30		2.700	1.380	0.064	0.037	0.045

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A5E3 LS27A5E3
44 10 00.0 092 34 00.0
MIDDLE FORK ZUMBRO RIVER
27 7.5 ORONOCO
T/ZUMBRO LAKE
RD BRDG UPSTRM US 52 BRDG WORONOCO
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	11 20		1.200	0.420	0.082	0.140	0.180
72/11/05	11 10		3.400	0.270	0.071	0.084	0.176
72/12/03	11 00		5.100	0.100K	0.021	0.132	0.154
73/02/04	11 25		3.600	0.280	0.091	0.132	0.160
73/03/04	10 45		2.000	7.200	2.700	0.620	1.050
73/04/08	11 10		5.700	0.300	0.018	0.060	0.087
73/04/20	08 55		8.700	1.540	0.100	0.042	0.170
73/05/05	09 25		7.700	1.100	0.032	0.084	0.192
73/05/20	10 25		4.600	0.100K	0.011	0.060	0.095
73/06/02	12 25		4.400	0.140	0.012	0.078	0.125
73/07/14	12 20		2.200	2.400	0.105	0.180	0.270
73/08/26	12 00		6.500	1.940	0.131	0.147	0.250
73/09/16	10 15		2.600	0.440	0.160	0.260	0.290

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A5F1 LS27A5F1
44 02 30.0 092 39 00.0
UNNAMED STREAM TRIB TO ZUMBRO RV
27 7.5 BYRON
T/ZUMBRO LAKE
CO HWY 5 BRDG N BYRON AROVESTP
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	12	15	0.585	0.450	0.075	0.054	0.082
72/11/05	09	20	0.470	0.380	0.042	0.061	0.075
72/12/03	10	15	1.660	0.100K	0.014	0.034	0.045
73/03/04	12	15	0.890	3.990	0.780	0.198	0.290
73/04/08	12	30	1.360	1.260	0.036	0.032	0.035
73/04/20	09	45	0.378	1.980	0.068	0.056	0.255
73/05/05	10	10	0.450	0.380	0.014	0.041	0.070
73/05/20	11	35	0.770	2.100	0.025	0.035	0.095
73/06/02	13	40	0.740	1.900	0.037	0.048	0.105
73/07/14	14	05	1.760	1.200	0.023	0.056	0.240
73/08/26	14	05	0.840	0.600	0.029	0.066	0.070
73/09/16	12	00	1.000	1.380	0.044	0.069	0.085

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A5F2 LS27A5F2
44 03 30.0 092 38 30.0
UNNAMED STRM TRIB TO ZUMBRO RV
27 7.5 BYRON
T/ZUMBRO LAKE
RD BRDG 1 MI N BYRON BELOW STP
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	12 00		1.400	4.800	1.050	0.170	
72/11/05	09 30		0.679	1.320	0.357	0.250	0.320
72/12/03	10 25		3.400	2.520	1.260	1.260	1.260
73/01/07	10 45		3.300	3.400	2.100	1.300	1.400
73/02/04	13 20		2.500	4.300	3.000	1.470	1.570
73/03/04	12 25		2.800	3.000	1.500	0.390	0.530
73/04/08	12 40		3.000	2.400	0.970	0.600	0.700
73/04/20	09 50		3.800	2.700	0.273	0.132	0.280
73/05/05	10 20		4.900	0.750	0.120	0.079	0.135
73/05/20	11 30		3.900	4.100	0.480	0.310	0.460
73/06/02	13 35		4.100	3.350	1.030	0.394	0.620
73/07/14	13 55		2.000	7.500	3.400	2.300	2.700
73/08/26	14 00		2.600	1.760	0.530	0.220	0.280
73/09/16	11 50		1.820	3.000	1.680	1.080	1.200

STORET RETRIEVAL DATE 74/10/30

27ASG1 LS27ASG1
44 11 30.0 092 30 00.0
DRY RUN CREEK
27 7.5 ORONOCO
T/ZUMBRO LAKE
CO HWY 127 BRDG 2 MI NE OF ORONOCO
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	10 40		0.560	0.100K	0.050	0.044	0.046
72/11/05	10 30		2.160	0.730	0.066	0.092	0.152
72/12/03	10 35		1.300	0.100K	0.005K	0.037	0.044
73/01/07	14 05		2.800		0.022	0.049	0.060
73/02/04	11 00		2.700	0.100K	0.015	0.031	0.035
73/03/04	10 15		1.800	7.500	2.800	0.780	1.000
73/04/08	10 50		2.200	1.050	0.017	0.046	0.063
73/04/20	08 35		2.900	2.250	0.058	0.054	0.065
73/05/05	09 05		3.700	0.320	0.018	0.075	0.090
73/05/20	09 50		2.700	0.140	0.013	0.043	0.065
73/06/02	12 00		2.500	2.000	0.033	0.051	0.080
73/07/14	11 55		2.800	1.150	0.043	0.037	0.050
73/08/26	11 20		2.600	0.100K	0.040	0.074	0.085
73/09/16	09 40		3.100	0.900	0.038	0.110	0.220

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

33

27A551 AS27A551 P053766
44 04 00.0 092 28 00.0
ROCHESTER
27 15 ROCHESTER
T/ZUMBRO LAKE
S FORK ZUMBRO
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/01/25	08 00								
CP(T)-			4.600	13.000	2.600	10.400	12.600	8.540	8.240
73/01/26	08 00								
73/02/27	08 00								
CP(T)-			3.300	16.400	4.100	14.000	14.000	8.420	8.080
73/02/28	08 00								
73/03/28	08 00								
CP(T)-			1.900	19.000	5.900	14.000	14.500	6.120	9.580
73/03/29	08 00								
73/04/29	08 00								
CP(T)-			3.800	15.000	2.300	7.715	13.500	8.390	8.670
73/04/30	08 00								
73/07/04	08 00								
CP(T)-			4.500	11.000	0.320	10.400	11.000	7.350	9.020
73/07/05	08 00								
73/08/14	08 00								
CP(T)-			2.500	13.200	0.770	6.200	9.900	9.040	8.340
73/08/15	08 00								
73/09/13	08 00								
CP(T)-			5.200	13.800	3.280	13.200	13.600	8.850	9.320
73/09/14	08 00								
73/10/15	08 00								
CP(T)-			4.900	15.000	4.450	5.300	10.500	12.600	9.280
73/10/16	08 00								
73/11/14	08 00								
CP(T)-			2.800	17.000	3.900	9.200	14.000	9.280	8.820
73/11/15	08 00								
73/12/14	08 00								
CP(T)-			1.680	19.500	5.850	9.800	16.500	7.790	8.500
73/12/15	08 00								
74/02/27	24 00								
CP(T)-			0.400	18.500	4.400	10.500	15.000	8.230	8.000
74/02/28	24 00								
74/04/06	08 00								
CP(T)-			3.840	13.600	0.790	5.200	11.500	8.810	8.000
74/04/07	08 00								

STORET RETRIEVAL DATE 74/10/30

34

274552 AS274552 P001419
44 02 30.0 092 39 00.0
BYRON
27 7.5 BYRON
T/ZUMBRO LAKE
UNNAMED STREAM
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/01/31 11 00 CP(T)- 73/01/31 13 00			0.060	23.000	8.540	6.360	7.800	0.150	
73/03/09 11 00 CP(T)- 73/03/09 13 00			0.090	20.500	5.800	6.400	7.500	0.160	0.150
73/03/30 11 00 CP(T)- 73/03/30 13 00			2.300	23.100	4.500	3.550	7.250	0.150	0.160
73/04/27 11 00 CP(T)- 73/04/27 13 00			2.600	17.700	1.630	2.700	7.100	0.180	0.170
73/06/05 11 00 CP(T)- 73/06/05 13 00			2.200	15.000	1.100	2.200		0.180	0.200
73/06/29 11 00 CP(T)- 73/06/29 13 00			0.220	16.800	5.300	4.500	6.700	0.165	0.170
73/08/01 11 00 CP(T)- 73/08/01 13 00			0.150	19.800	4.450	3.150	8.000	0.170	0.175
73/08/31 11 00 CP(T)- 73/08/31 13 00				18.900	2.700	6.520	8.050	0.200	0.180
73/10/01 11 00 CP(T)- 73/10/01 13 00			0.030	14.000	2.600	3.000	7.400	0.200	0.180
73/11/01 11 00 CP(T)- 73/11/01 13 00			0.100	25.000	5.600	4.100	9.100	0.180	0.180
73/11/30 11 00 CP(T)- 73/11/30 13 00			0.090	17.000	2.520	3.000	7.100	0.180	0.190
73/12/28 11 00 CP(T)- 73/12/28 13 00			1.600	18.500	1.200	3.360	5.000	0.170	0.180